view 292. A yaw icon generator 346 receives a yaw adjustment 183 and provides data for displaying a top icon 376 and a bottom icon 378 showing the yaw orientation (Fig. 7). A clinician uses the icons for better understanding of the images. Furthermore, a clinician uses the icons to steer and direct the acoustic beam to a selected value of interest or to locate and orient the images relative to the orientation of transducer array 42.

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REMARKS

The specification has been amended to refer to the drawings as they are labeled. Specifically, instead of referring just to "Fig. 5" or "Fig. 5A", reference is now made as appropriate to individual drawings of the set of Figs. 5(1), 5(2), 5(3), 5(4), 5(5), 5A(1) and 5A(2), which is how the drawings are labeled. Reference to two patent applications has been updated by the patent numbers of the issued patents.

The Examiner's presumption that the claimed subject matter has been commonly owned at all relevant times is correct.

Claims 1-29 were rejected under 35 U.S.C. §102(b) as being anticipated by US Pat. 5,398,691 (Martin et al.) Claim 1 describes a semi-invasive ultrasound imaging system for imaging biological tissue, comprising a probe including an elongated body with a distal end comprising a two-dimensional ultrasound transducer array; a transmit beamformer connected to the transducer array and constructed to transmit several ultrasound beams over a selected azimuthal range and a selected elevation range of locations; a receive beamformer, connected to the transducer array, constructed to acquire ultrasound data from echoes reflected over a selected tissue volume delineated by the emitted ultrasound beams and a selected sector scan depth and synthesize image data from said acquired ultrasound data; and an image generator constructed to receive said image data and generate at least one image of the selected tissue volume that are displayed on an image display. This invention represents the latest evolution of imaging TEE probes, which began with a single fixed one dimensional array transducer that imaged a single plane constrained by the articulation range of the probe. The next development was a biplane probe, with two one dimensional arrays that could selectably image either a transverse or a

longitudinal plane upon activation of the appropriate array. The third development was the multiplane TEE probe, with a mechanism for the one dimensional array that permitted the user to rotate the image plane from transverse to longitudinal or any orientation in between. By progressively rotating the array and its image plane and acquiring a series of planar images, a static 3D image could be produced as described in US Pat. 5,181,514 (Solomon et al.) However, the multiplane TEE probe requires a complex mechanism to rotate the array. The mechanism includes a rotating platform beneath the array and a control mechanism extending from the tip of the probe where the array is located to the control handle of the probe. This mechanism necessarily increases the bulk, complexity, and cost of the probe. The present inventors have overcome these disadvantages by utilizing a two dimensional array transducer, which can transmit beams in a variety of azimuthal and elevation directions, enabling the scanning of different planes in a 3D volume or the scanning of the full volume itself. Since the probe of this invention utilizes both elevation and azimuthal beam transmission, there is no need for the bulky, complex, costly mechanism of prior art probes. In addition, with both elevation and azimuth scanning it becomes possible to scan different planes or a volume in real time, rather than the static 3D imaging capability of prior art devices.

The Martin et al. patent describes just the type of prior art device over which the present invention provides its advantages. The Martin et al. device uses a one dimensional array transducer to scan a single image plane, as can be seen by image plane 60 in Fig. 3 of Martin et al. As in other multiplane TEE probes of the prior art, the array can be rotated. In addition it appears that the array can be tilted about an axis 70. These motional attributes of the array require a complicated mechanism as shown in the vertically exploded view of Fig. 5. It is just this sort of mechanical complexity which is avoided by the claimed invention. Since Martin et al. do not show or suggest the use of a two-dimensional transducer array or the transmission of beams over a selected azimuthal range and a selected elevation range of locations, it is respectfully submitted that Martin et al. cannot anticipate Claim 1 and its dependent Claims 2-29.

Claims 30-48 were rejected under 35 U.S.C. §103(a) as being unpatentable over Martin et al. in view of US Pat.

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4,757,821 (Snyder). Claim 30 describes a semi-invasive ultrasound imaging method, comprising introducing into the esophagus a probe and positioning a two-dimensional ultrasound transducer array at a selected orientation relative to an tissue region of interest; transmitting ultrasound beams over a plurality of transmit scan lines from said transducer array over a selected azimuthal range and a selected elevation range of locations; acquiring by the transducer array ultrasound data from echoes reflected from a selected tissue volume delineated by the azimuthal range, the elevation range and a selected sector scan depth and synthesizing image data from said acquired ultrasound data; generating from said image data at least one image of the selected tissue volume; and displaying the generated image. As indicated above, the Martin et al. patent does not show or suggest the positioning of a two-dimensional ultrasound transducer array, nor does it show or suggest transmitting ultrasound beams over a plurality of scanlines selectable by azimuthal and elevation range. The Snyder device does not show or suggest any of these elements either. Snyder has a probe with a ring-shaped transducer 36 which radiates energy that is dispersed in a cone-shaped space extending from a conical reflector as indicated by lines 82. Returning echoes along a cone indicated by lines 88 are received by a second ring-shaped transducer 52. Thus, only single element transducers are used by Snyder. Furthermore, his probe is incapable of imaging and is used only to monitor blood flow rate by the Doppler technique. For these reasons it is respectfully submitted that the combination of Martin et al. and Snyder cannot render Claim 30 and its dependent Claims 31-48 obvious.

In view of the foregoing remarks, it is respectfully submitted that Claims 1-29 are not anticipated by Martin et al. and that Claims 30-48 are not obvious in view of Martin et al. and Snyder. Accordingly it is respectfully requested that the rejection of Claims 1-29 and of Claims 30-48 be withdrawn.

In light of the foregoing amendment and remarks, it is respectfully submitted that this application is now in condition for allowance. Favorable reconsideration is respectfully requested.

Respectfully submitted,

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Version with markings to show additions (underlined) and deletions (bracketed).

Paragraph beginning on page 19, line 18:

Each intra-group receive pre-processor 220i may include a summing delay line, or several programmable delay elements connected to a summing element (a summing junction). Each intra-group receive processor 220i delays the individual transducer signals, adds the delayed signals, and provides the summed signal to one receive beamformer channel 225i. Alternatively, one intra-group receive processor provides the summed signal to several receive beamformer channels 225i of a parallel receive beamformer. The parallel receive beamformer is constructed to synthesize several receive beams simultaneously. Each intra-group receive pre-processor 220i may also include several summing delay lines (or groups of programmable delay elements with each group connected to a summing junction) for receiving signals from several points simultaneously, as described in detail in U.S. Patent 5,997,479 [Application Ser. No. 09/085,718, filed on May 28, 1998], which is incorporated by reference.

Paragraph beginning on page 24, line 20:

Control processor 140 selects the scanning sequence performed by beamformer 200. The transmit beamformer directs emission of the phased ultrasound beam along the scan lines over the ranges calculated for each sector. For each emitted scan line, the receive beamformer phases the transducer elements to detect the ultrasound echoes along a corresponding receive scan line. Alternatively, the receive beamformer synthesizes the scan data from several receive scan lines that are spaced over a selected angular distribution as is described, for example, in the U.S. Patent 5,976,089 [Application Serial No. 09/046,437, filed March 24, 1998], entitled "Increasing the Frame Rate of a Phased Array Imaging System," which is incorporated by reference. The RF data is filtered by a filter with a pass band of as much as 60% around the center frequency of as high as 10 MHz, or preferably a

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pass band of about 35% around the center frequency in the range of about 5 MHz to 7 MHz.

Paragraph beginning on page 25, line 14:

Referring to Figs. 5(1)-5(5), the receive beamformer 200B provides detected RF echo 15 signals to the image generator that includes a time gain compensator (TGC) 262, a lateral gain compensator (LGC) 264, and an elevation gain compensator (EGC) 266, which perform the corrections described above. The EGC 266 provides the compensated data to a B-scan signal processor 272, a C-scan signal processor 315, and boundary detectors 302 and 322.

Paragraph beginning on page 25, line 28:

Referring still to Figs. 5(1)-5(5), the image generator includes post processors 276 and 318, which receive filtered and compensated data from envelope detectors 274 and 317. Post processors 276 and 318 control the contrast of each data point by mapping the data onto a set of selected curves. After assigning a contrast level to each data point, a scan line buffer may be used to hold temporarily the data for one scan line.

Paragraph beginning on page 27, line 16:

As shown in Figs. 5(1)-5(5), B-scan boundary detector 302 includes a signal processor 304, a tissue indicator 306, a majority vote processor 308, and an edge indicator 310. U.S. Pat. 5,195,521, which is incorporated by reference, discloses a majority vote circuit and circuits for generating the ROI. Control processor 140 provides to boundary detector 302 RO1 enable output 176, line number output 171, and sector number output 174. Signal processor 304 derives from the RF data a characteristic sensitive to the difference between the echo from tissue and from blood in order to increase the accuracy of locating the tissue boundary. The characteristic is the amplitude of integrated backscatter from tissue and from blood. Signal processor 304 determines the amplitude of the integrated backscatter and provides it to tissue indicator 306. (Alternatively, tissue indicator 306 may receive the echo

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RF data directly.)

Paragraph beginning on page 30, line 32:

The imaging system 10 uses several icons to provide understandable images. Referring to Figs. 5(1)-5(5), 5A(1)-5A(2), and 7, an azimuthal icon generator 289 receives a pitch adjustment 181 and provides data for displaying a front azimuthal icon 370 for the front view (or a rear azimuthal icon for the rear view). An elevation icon generator 299 receives a roll adjustment 182 and provides data for displaying a left elevation icon 372 (shown in Fig. 7) for the left view 291 and a right elevation icon 374 for the right view 292. A yaw icon generator 346 receives a yaw adjustment 183 and provides data for displaying a top icon 376 and a bottom icon 378 showing the yaw orientation (Fig. 7). A clinician uses the icons for better understanding of the images. Furthermore, a clinician uses the icons to steer and direct the acoustic beam to a selected value of interest or to locate and orient the images relative to the orientation of transducer array 42.

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